The Ceramic Materials of Indiana

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THE CERAMIC MATERIALS OF INDIANA

The raw materials suitable for the manufacture of ceramic wares in Indiana include a variety of substances. Clays and shales which are found in the rock strata vary in age from the Pleistocene to the Ordovician. The raw materials include clays and shales from a large number of geological formations, under clays from the Pennsylvanian or Coal Measures, clays from the glacial drift, and kaolin from horizons in the Mississippian and Pennsylvanian strata.

Indiana produces a large variety of ceramic wares and is the 7th state in rank in ceramic production in the United States. The annual production of common, front, glazed, mat, rug, pressed, vitrified, ornamental and fire brick reaches a value of many millions of dollars. The manufacture of agricultural tile, wall tile, floor tile, encaustic tile, fire-proofing, terra cotta, sewer pipe, stove and furnace linings, glass pots and silo staves is of great importance. Pottery products manufactured in the state include earthenware, stoneware, yellow and Rockingham ware, white ware, C. C. ware, white granite, semi-porcelain, sanitary ware and porcelain electrical ware.

The quantity and quality of the raw materials and the abundance of low cost fuels in Indiana justify a much larger production of ceramic wares. Whenever market conditions justify, increased production can be attained in plants already in operation and in those which can readily be established. The object of this circular is to present some of the facts regarding the properties and distribution of the raw materials of the ceramic industry in Indiana.

Geographic Distribution of Materials

All parts of Indiana contain some materials which may be used for some form of ceramic wares. Some of these materials may be used as they are taken from the earth without special preparatory processes, others contain impurities which must be removed before they can be used successfully.

The Borden Shales

The Borden formation contains beds of shale which are serviceable for ceramic purposes. This formation extends from the southernmost point of Harrison County into Jasper County in the northern part of Indiana. The shales have been used for ceramic purposes at a number of points between New Albany in Floyd County and Attica in Fountain County. The outcrop of the formation north of Morgan County is largely concealed by glacial drift except where the major streams have cut through the drift to the bedrock.

The Borden shale and the residual clays from it have been used for a variety of ceramic wares, although its principal uses have been in the manufacture of brick and tile. The varieties of brick which

have been manufactured from it include common red brick, vitrified brick, rug, mat and glazed brick. The varieties of tile which have been manufactured include wall tile, floor tile, roofing tile, and sewer pipe.

Laboratory experiments have demonstrated that some of the outcrops of the Borden contain shales which may be used in the manufacture of earthenware and of stoneware. Experiments conducted in the use of some of the more fusible shales have demonstrated that they can be used for slip clays in the preparation of glazes. The glazes produced vary in color from light yellow, through dark browns to black.

Physical Properties. The raw Borden shale is a gray or greenish gray color on recently exposed outcrops. The shale weathers to a yellow colored clay. The color of the product is a light to cherry red at the fusion point of cone 1. Incipient fusion often occurs at this temperature. Vitrification often occurs at cone 5. Chocolate to dark red colors may be obtained in some of the shales at temperatures higher than the fusion point of cone 5. Slip clays and salt glazes may be used with satisfactory results. The linear dry shrinkage ranges from 5 to 7 per cent.

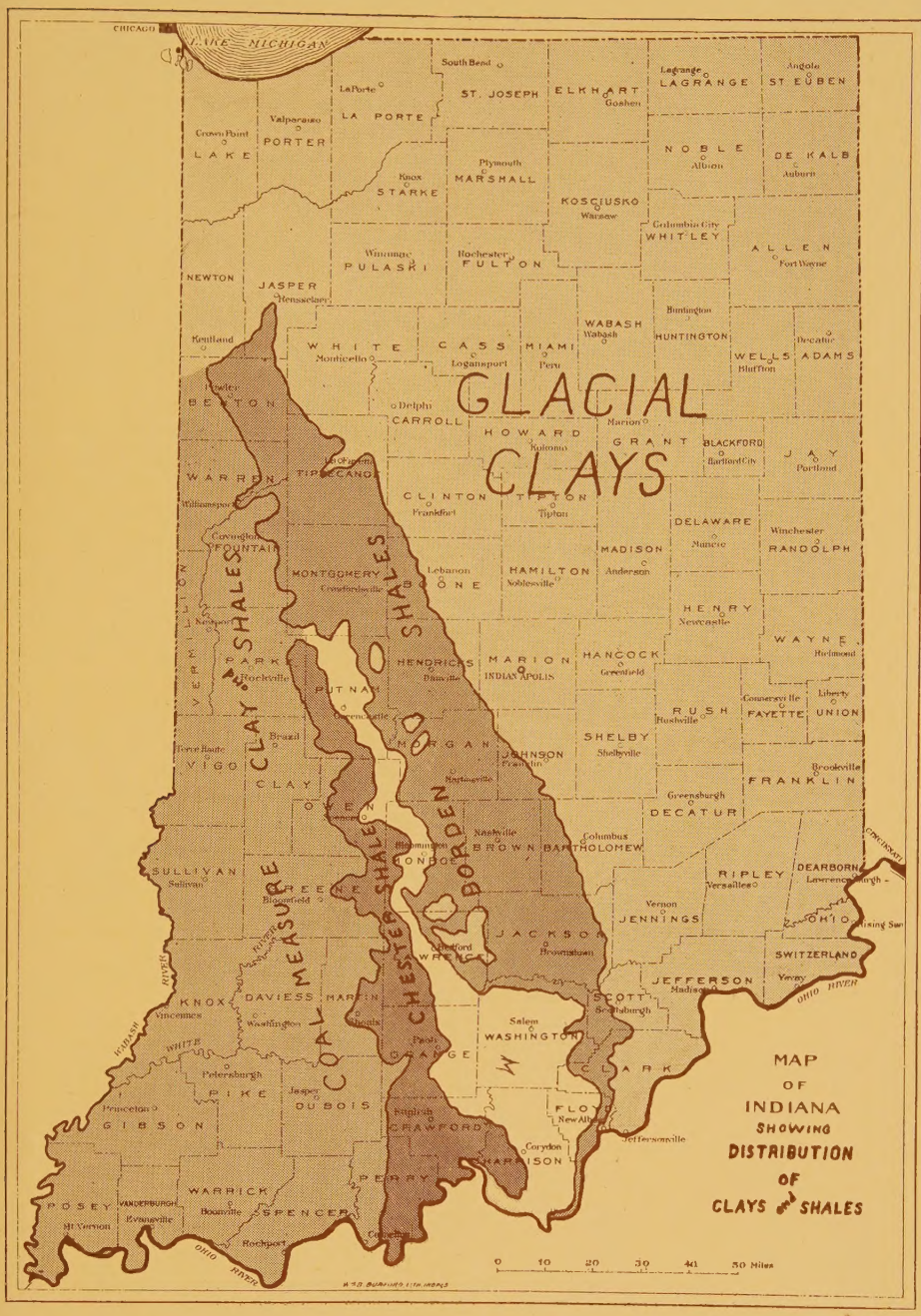
Chemical Composition. The analyses of samples of the Borden shale taken from various points in the outcrop of the formation are given in the following table:

Analyses of Samples of Borden Shales*

Name	Town	County	Silica	Titanium oxide	Alumina	Water (Combined)	Clay Base and Sand (Total)
Arthur Hadley	Danville	Hendricks	70.84	.18	14.73	3.32	89.07
Branch & Son	Martinsville	Morgan	70.60	.43	13.89	3.19	88.11
Goetz Dry Pressed Brick Co.	New Albany	Floyd	63.88	.91	17.85	4.99	87.63
Jas. McLarey	Bloomington	Monroe	58.22	1.15	19.63	6.61	85.61
W. H. Gregory	Heltonville	Lawrence	68.90	.....	17.20	3.97	90.07

Name	Ferric oxide	Ferrous oxide	Lime	Magnesia	Potash	Soda	Fluxes (Total)	Carbon dioxide
Arthur Hadley	.....	4.82	.38	1.36	3.15	1.42	11.13	.21
Branch & Son	2.33	3.56	.60	.50	2.76	1.60	11.35	.51
Goetz Dry Pressed Brick Co.	5.38	.....	.38	1.47	3.98	1.29	2.50	.....
Jas. McLarey	5.88	.....	1.95	2.10	3.93	.68	14.54	.....
W. H. Gregory	5.05	1.05	.....	1.95	.85	1.00	9.90	.....

*See Handbook of Indiana Geology, page 649.


CHICAGO
LAKE MICHIGAN
LAKE
PORTER
LA PORTE
ST. JOSEPH
ELKHART
LAGRANGE
STEUBEN
NOBLE
DE KALB
STARKE
MARSHALL
KOSCIUSKO
WHITLEY
ALLEN
PULASKI
FULTON
NEWTON
JASPER
WHITE
CASS
MIAMI
WABASH
HUNTINGTON
WELLS
ADAMS
GLACIAL
CLAYS
BENTON
CARROLL
HOWARD
GRANT
BLACKFORD
JAY
WARREN
TIPPECANOE
CLINTON
TIPTON
DELAWARE
RANDOLPH
MADISON
HAMILTON
MONTGOMERY
BOONE
HENRY
WAYNE
PARKE
HENDRICKS
MARION
INDIANAPOLIS
HANCOCK
PUTNAM
RUSH
FAYETTE
UNION
SHELBY
VIGO
CLAY
MORGAN
JOHNSON
FRANKLIN
DECATUR
SULLIVAN
GREENE
BROWN
BARTHOLOMEW
RIPLEY
DEARBORN
JENNINGS
OHIO
JACKSON
SWITZERLAND
JEFFERSON
KNOX
DAVIESS
MARTIN
SCOTT
WASHINGTON
CLARK
PIKE
DUBOIS
FLOYD
GIBSON
CRAWFORD
HARRISON
WARRICK
PERRY
POSEY
VANDERBURGH
SPENCER
COAL MEASURE SHALES
CHESTER SHALES
BORDEN
CLAY SHALES
MAP OF INDIANA SHOWING DISTRIBUTION OF CLAYS AND SHALES
0 10 20 30 40 50 Miles

The Chester Shales

The uppermost beds of the Mississippian rocks in Indiana contain shales, some of which are serviceable for ceramic purposes. These shales outcrop in a belt which extends from the southern portion of Perry County to the southwestern part of Putnam County. Beyond this point the outcrop is concealed by younger formations.

The formations of the Chester which contain shales are the Mooretown, the Sample, the Elwren, the Indian Springs, and there are a number of unnamed shale intervals in the Upper Chester.

Shales from the Chester formations may be used in the manufacture of common, face, and vitrified brick. The color of the ware will vary from nearly pure white to pink or salmon. The shales may be used also in the manufacture of wall tile, floor tile, roofing tile, silo staves, and sewer pipe. Experiments in the laboratory have shown that these shales may be used also in the manufacture of stoneware. In some places these shales appear at the surface near the outcrop of under clays of the Coal Measures, and better ceramic products may be obtained by the mixture of the shales with the clays. Since the quantity and quality of the Chester shales vary much from point to point in the geographical distribution, care should be exercised in the location of plants by first determining the amount and quality of deposit.

Physical Properties. The color of the shales is generally a gray, light blue or light green. Other shades such as yellow, brown, and maroon are present locally. The slaking time varies but is usually low for a shale. The amount of water required for a good degree of plasticity is normally about twenty per cent of the weight of the clay. The loss in weight in passing from a plastic condition to a vitrified product is rarely more than twenty per cent. The color of the more aluminous shales after reaching the vitrified stage is gray or more rarely white. Fluxing substances may produce other colors such as salmon, yellow, pink, or red. The fusion point of the shales of the better grade ranges from pyrometric cone 10 to cone 22. Mixtures of the shale with Indiana halloysite attain higher temperatures.

Chemical Composition. The analyses of five samples of the Chester shales are given in the following table:

Analyses of Samples of Chester Shale*

Constituents	No. 1 Per cent	No. 2 Per cent	No. 3 Per cent	No. 4 Per cent	No. 5 Per cent
Silica	61.24	64.57	58.40	58.68	59.67
Aluminium oxide	18.38	18.67	20.70	21.39	19.75
Iron oxide	4.76	6.22	6.58	6.22	7.32
Calcium oxide	0.70	0.10	0.15	0.14	0.20
Magnesium oxide	1.94	0.65	0.86	0.82	1.02
Alkalies	3.94	2.62	3.16	2.59	2.42
Loss on ignition	10.04	7.17	8.89	8.90	8.60
Sulphur trioxide	.00	tr.	1.26	1.25	1.02
Total	101.00	100.00	100.00	100.00	100.00

*See Handbook of Indiana Geology, page 690.

By weathering and washing the shales thoroughly some impurities may be removed and a more refractory product obtained from the shales in some of the outcrops.

Pennsylvanian (Coal Measure) Shales

The shales which are associated with the coal beds of Indiana are often of a quality which will produce a good ceramic product. These shales are serviceable in the manufacture of tile, paving and building brick, sewer pipe, and silo staves. Ceramic plants which make use of these shales are located for the most part in the area of outcrop of the Pennsylvanian strata. The Montezuma, the Brazil, and the Terre Haute districts are important ceramic centers where these shales have been utilized.

Physical Properties. The color of the shales is gray or bluish gray. The shales are plastic and slake readily under weathering action. The color of the ware varies from light yellow or salmon to dark red. The specific gravity is about 2.40 and the linear shrinkage varies from 6 to 7 per cent. The product usually has light yellow or light salmon color at cone 1, and brownish gray at cone 20. A vitrified ware is produced at the higher temperature.

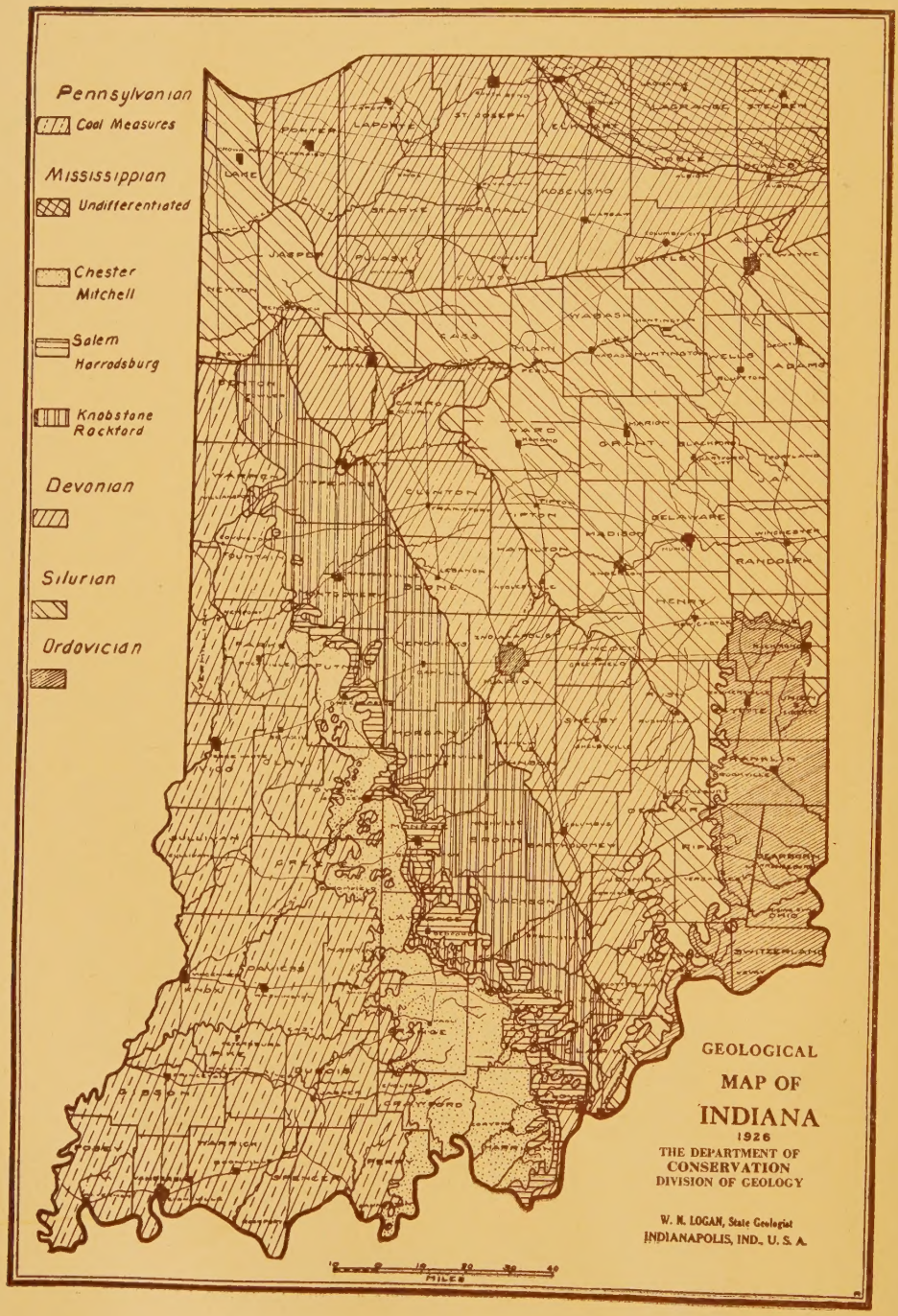
Chemical Composition. The analyses of samples of the Pennsylvanian shales are included in the following table:

Analyses of Samples of Pennsylvanian Shales*

Name	Town	County	Silica	Titanium oxide	Alumina	Water (Combined)	Clay Base and Sand (Total)
Wabash Clay Co.	Veedersburg	Fountain	59.55	1.00	16.21	5.62	82.38
(2) Mecca Coal & Mining Co.	Mecca	Parke	59.77	.8	20.60	4.53	85.70
(6) Burns & Hancock Land	Montezuma	Vermillion	46.07	1.19	24.22	9.76	81.24
Buckskin Mine	Buckskin	Gibson	57.60	.89	24.74	8.14	91.37
American Cannel Coal Co.	Cannelton	Perry	53.26	1.05	25.77	7.00	87.08

Name	Ferric oxide	Ferrous oxide	Lime	Magnesia	Potash	Soda	Fluxes (Total)	Carbon dioxide
Wabash Clay Co.	2.18	7.13	.75	1.58	2.81	.28	14.73	3.15
(2) Mecca Coal & Mining Co.	2.22	3.70	.64	1.98	3.10	.85	12.49	.90
(6) Burns & Hancock Land	9.65	.34	.19	1.31	1.66	2.76	15.91	2.87
Buckskin Mine	.15	2.41	.70	1.20	3.40	.99	8.85	.....
American Cannel Coal Co.	3.32	3.82	.32	1.90	2.54	.44	12.34	1.10

*See Handbook of Indiana Geology, page 649.


Pennsylvanian
Coal Measures
Mississippian
Undifferentiated
Chester
Mitchell
Salem
Harrodsburg
Knobstone
Rockford
Devonian
Silurian
Ordovician
GEOLOGICAL
MAP OF
INDIANA
1926
THE DEPARTMENT OF
CONSERVATION
DIVISION OF GEOLOGY
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INDIANAPOLIS, IND., U. S. A.
MILES

Pennsylvanian Under Clays

Beneath many of the coal beds of the Pennsylvanian formations of Indiana are beds of plastic gray clays which supply some of the most important ceramic materials of the state. The thickness of the beds of clay varies from a few feet to eight feet. These clays may be used in the manufacture of a large list of ceramic products, among others wall, roof and floor tile, pottery, terra cotta, sewer pipe, face, common, front and glazed brick, electric conduits, silo staves, flue linings, coping and culvert pipes.

Physical Properties. The under clays have an excellent degree of plasticity, are fine of grain, and are generally free from concretions or particles which are likely to cause imperfections in wares. They are gray in color, imperfectly laminated, and have a smooth, soap-like feel. They are often irregularly jointed and slicken-sided. The linear dry shrinkage is generally under five per cent. The color of the product at cone 1 is white and often remains white up to cone 20. The fire shrinkage is usually less than three per cent, and the loss of volatile matter less than six per cent. The clay usually vitrifies at cone 20 and presents a strong body free from imperfections.

Chemical Composition. The composition of the under clays is variable. Variations occur as between beds and between points in the same bed. The percentage of alumina is usually between 20 and 25; silica between 58 and 65; the fluxes between three and four; and the loss on ignition between seven and ten.

The analyses of samples of the under clays are contained in the following table:

Analyses of Samples of Pennsylvanian Under Clays*

Name	Town	County	Silica	Titanium oxide	Alumina	Water (Combined)	Clay Base and Sand (Total)
John R. Teegarden	Kingman	Fountain	71.91	.31	17.62	5.37	95.21
No. 12 Mecca Coal & Mining Co.	Mecca	Parke	54.46	1.20	25.71	8.50	89.87
Cayuga Brick & Coal Co.	Cayuga	Vermillion	55.09	1.20	20.76	7.01	84.06
Potters Clay-Bockting Bros.	Huntingburg	Dubois	69.23	1.50	18.97	5.46	95.16
American Cannel Coal Co.	Cannelton	Perry	57.59	1.10	21.70	6.78	87.15

Name	Ferric oxide	Ferrous oxide	Lime	Magnesia	Potash	Soda	Fluxes (Total)	Carbon dioxide
John R. Teegarden	2.55	.40	.43	.17	2.00	.15	5.70	.....
No. 12 Mecca Coal & Mining Co.	5.51	.91	.24	.83	2.68	.33	10.50	.....
Cayuga Brick & Coal Co.	3.00	4.01	1.51	1.18	2.36	.34	12.40	3.04
Potters Clay-Bockting Bros.	1.57	.55	.12	.36	2.27	.33	5.20	.....
American Cannel Coal Co.	2.26	4.11	.32	1.12	2.16	.33	10.30	1.73

*See Handbook of Indiana Geology, page 650.

Pleistocene and Recent Clays

Surface clays in many parts of the glaciated region have been used in the manufacture of brick and agricultural tile. In the non-glaciated region of Indiana there are residual clays derived from the decomposition of limestones and other clay-bearing rocks. These clays have been used in the manufacture of common brick and drain tile.

Physical Properties. These clays vary much in their physical properties due to the conditions under which they have been formed. Some of the glacial clays are high in lime and fuse at low temperatures. Some have a high silica content and are lacking in bonding power. Others contain coarse particles which interfere with the processes of manufacture. Other deposits are plastic, have good bonding and drying qualities, and produce a satisfactory product without expensive preparatory processes.

Chemical Composition. The analyses of some samples of the Pleistocene and Recent clays are given in the following table:

ANALYSES OF SAMPLES OF PLEISTOCENE AND RECENT CLAYS*

NAME	Town	County	Silica	Titanium oxide	Alumina	Water (Combined)	Clay Base and Sand (Total)
Surface Drift	Rockville	Parke	66.84	.....	13.64	4.22	84.70
Surface Loess	Princeton	Gibson	71.20	.88	18.56	6.30	96.94
National Stone Co	Bloomington	Monroe	72.56	.31	10.44	4.54	87.85
Jessup Land	Richmond	Wayne	67.76	.89	13.69	7.10	89.44
Roeske Bros	Michigan City	Laporte	50.47	1.45	12.77	3.14	67.83

NAME	Ferric oxide	Ferrous oxide	Lime	Magnesia	Potash	Soda	Fluxes (Total)	Carbon dioxide
Surface Drift	9.40	.....	1.36	Tr.	.64	3.34	14.74	.....
Surface Loess	1.34	.15	.14	.52	.32	1.26	3.73	.....
National Stone Co	7.45	.43	.82	1.09	2.05	.73	12.57	.....
Jessup Land	5.09	.46	.94	.51	3.26	.51	10.77	.....
Roeske Bros	2.44	2.52	8.17	5.22	3.70	.73	22.78	9.80

*See Handbook of Indiana Geology, page 650.

Production of Clays and Clay Products in Indiana

Raw clays are produced in Indiana and used for ceramic purposes in other states. The amount of such clay reaching the market each year depends upon the general commercial condition. The amount of clay disposed of in this way is between 200,000 and 250,000 short tons annually and the value is generally in excess of one dollar per ton.

Clay Products. Indiana is an important producer of ceramic products. Among the states it ranks seventh in the value of these products. The number of firms which report the production of clay wares is 94. The value of the brick and tile produced in Indiana annually is $14,230,400.00. The value of ceramic products listed under pottery is $3,625,571.00 per year. The total value of all ceramic products is $17,855,971.00.

AVAILABLE GEOLOGICAL REPORTS

The reports and maps listed below may be obtained from the office of the State Geologist, Room 135, State Capitol.

Separate volumes including the reports of the State Geologist were published until 1916. The following are available:

7th (1875)	$2.00	24th (1899)	$2.00
15th (1885-6)	.50	25th (1900)	2.00
16th (1888)	.50	26th & 27th (1901-2)	3.00
17th (1891)	.50	30th (1905)	3.00
19th (1894)	.50	39th (1914)	1.50
21st (1896)	2.50	40th (1915)	.50
23rd (1898)	10.00	41st (1916)	free

Recent annual reports of the State Geologist, including miscellaneous papers, have been published in the following available reports of the Conservation Department, which are free:

3rd (1921) Gold in Indiana; The New Providence Shale; The St. Louis ls.
4th (1922) The New Albany Shale; Peat Deposits of Indiana.
5th (1923) Petroleum Conservation.
6th (1924) Laws Affecting Oil and Gas Operations in Indiana.
7th (1925) Coal Losses of Indiana.
8th (1926) Report on Indiana Caves, including Marengo.
9th (1927) Subterranean Drainage Phenomena.
10th (1928) Geological Conditions in the Siosi Oil Field.
11th (1929) The Mineral Fuel Resources of Indiana.

The following special reports have been published separately:

Kaolin in Indiana (1919)—$0.25.

Handbook of Indiana Geology (1922)—$3.00 in Indiana; $5.00 to non-residents. Includes geography, physiography, hydrology, stratigraphy, paleontology, economic geology and oil shales of Indiana.

Petroleum Industry in Indiana in 1923—free.

Geological Conditions in the Oil Fields of Southwestern Indiana (1924)— $0.50 in Indiana; $0.75 to non-residents.

Laws and Regulations Affecting Oil and Gas Operations in Indiana (1924)—free.

Geology of the Deep Wells of Indiana (1926)—$1.00.

Regulations concerning plugging of abandoned gas and oil wells and filing of deep well records, with blank well log forms—free.

Geology of the Silurian Rocks of Northern Indiana (1928)—$1.00.

Indiana Oolitic Limestone Map of Lawrence County (1928)—$1.00 on bond stock, $2.00 on enamel stock.

Indiana Oolitic Limestone Map of Monroe-Owen Counties (1928)—$1.00 on bond stock, $2.00 on enamel stock.

The Geological History of the Vertebrates of Indiana (1929)—Cloth bound, $1.25; Paper bound, $1.00.

U. S. Geological Survey topographic sheets of portions of Indiana are sold through this office for 10c each.